SIGMA XI QUARTERLY

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SPECIAL IN THIS ISSUE

BUSH ON ENGINEERING RESEARCH

FAUST ON THE HUMAN BODY AND DISEASE

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OUR NEW CHAPTERS

It is a privilege to announce in this issue of the QUARTERLY the installation of two additional chapters of our great society—Massachusetts Institute of Technology and Tulane University. The organization now numbers sixty-four chapters with a total enrollment of approximately twelve thousand members and associates. There are thirty-two Sigma Xi clubs in as many institutions with a total membership of approximately seven hundred. The list of institutions in which Sigma Xi is exerting a stimulating scientific influence comprises the leading research and educational centers of the western hemisphere. These groups of scientists are not only promoting the spirit of research, they are also spreading the scientific attitude of mind in the general public—an important factor in the work of Sigma Xi. The story about Sigma Xi to be told at the semi-centennial in 1936 at the place of its founding will be full of interest and inspiration.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY CHAPTER—SIGMA XI'S SIXTY-THIRD

The installation of this important chapter occurred April 5, 1934 in the Eastman Research Laboratory of the institute. The charter of the chapter was presented by the National Secretary, Edward Ellery of Union College; and the charge to the chapter was given by the National President, George Howard Parker of Harvard University. The officers of the chapter are: President, Prof. Dugald C. Jackson, Sigma Xi at Cornell and Wisconsin; vice-president, Prof. Hervey W. Shimer, Sigma Xi at Columbia; secretary-treasurer, Prof. George Scatchard, Sigma Xi at Columbia.

At the installation dinner, President Compton presided. Greetings from neighboring chapters were brought by Prof. Russell Gibson of Harvard, Prof. R. B. Lindsay of Brown, Prof. Barnett F. Dodge of Yale and Prof. Theodore H. Morgan of Worcester Polytechnic Institute. Brief addresses were given by Prof. George Howard Parker, National President, and by Prof. Dugald C. Jackson the chapter president. The address of the evening was given by Dean Vannevar Bush of the institute (page 45, this issue).

THE TULANE CHAPTER—SIGMA XI'S SIXTY-FOURTH

The installation of the chapter at this justly famous university of the South took place in the administration building of Newcomb College, April 13, 1934. The National Secretary, Prof. Edward Ellery, of Union College, was the installing officer. He presented the charter and gave the charge to the chapter. The officers elected were: President, Prof. Herbert E. Buchanan, Sigma Xi at Chicago and Wisconsin; vice-president, Dr. Ernest C. Faust, Sigma Xi at Illinois and Johns Hopkins; secretary-treasurer, Prof. H. N. Gould, Sigma Xi at California. Guests at the installation were Prof. L. C. Price, University of Arkansas, Mrs. Marshall Ballard (Cornell) of New Orleans, Mrs. W. L. Duren (Chicago) of New Orleans, Dr. Lawrence Martin of the Illinois Chapter, and Prof. and Mrs. A. H. Wright (Cornell) of Ithaca.

At the installation dinner, Dr. Alton Ochsner, Professor of Surgery in the Medical School, acted as toastmaster, and toasts were given as follows:

From Phi Beta Kappa, Prof. Leon Ryder Maxwell.

For the general officers of Sigma Xi, Dr. Charles F. Craig, of the School of Medicine.

For the Alpha Chapter, Prof. William B. Gregory, of the College of Engineering.

From the Board of Administration, Mr. J. Blanc Monroe, member of the Board.

A public meeting was held in Dixon Hall on the Newcomb College campus at which Dean Douglas C. Anderson, acting president of Tulane University presided. The principal address was given by Dr. Ernest C. Faust (see page 53, this issue).

TRENDS IN ENGINEERING RESEARCH*

VANNEVAR BUSH

Dean of Engineering and Vice-President of the Massachusetts Institute of Technology

In these rapidly changing times there is little agreement as to the underlying course of the shifting political and economic scene. The perspective of the historian alone will be capable of accurately estimating the present direction of affairs. On one matter only is there now general agreement, namely, that when stability again comes, if it does, we shall live in an altered world.

To prophesy at the moment in regard to any particular feature of our complicated scheme of civilization is to prophesy at random. Under such conditions there are always plenty of random prophets, for their risk is no greater than usual, while the temptation is unduly strong. The old almanacs have always contained long range weather predictions which, by grace of skillful indefiniteness and ambiguity, work out rather well. But prophets who insist on a full basis of reason are now silent.

It is possible to note present trends. To consider that these will necessarily lead to the results which would be expected in a normal world is, however, to neglect the fact that strong uncontrolled forces of change are at large. It is as though one were watching a rosebud unfolding, and the weather bureau were simultaneously flying hurrican warnings. The hurricane may pass away, or it may not, but the normal development of the flower is severely conditioned.

The trends in engineering research in this country in recent years, taken by themselves, are highly encouraging. Attractive opportunity lies ahead, if the storm passes and the flower matures in gentle winds and rain, and warm sunshine.

Engineering research is not always closely defined; and indeed it is not possible to delimit it absolutely. It will be well to specify as accurately as possible what is meant by research in the field of engineering, for it is of relatively recent origin, and in its present form a new thing under the sun. Research is diligent systematic search for new facts or relationships. Engineering in its modern sense is the application of science in an economic manner for the benefit of man. Thus research in the application of science, with the economic aspect prominent, is the type of research which is treated in this paper.

It should be noted that the definition does not involve the type of researcher. Scientists may very properly at times carry on engineering research, and engineers, sometimes do research in science. There is an economic aura to all research, if only in the conditions under which it is conducted and limited; but in engineering research the economic factor is a part of the problem itself.

* Address at the installation of the Massachusetts Institute of Technology, Chapter of Sigma Xi, April 5, 1934.

EASTMAN RESEARCH LABORATORY
Massachusetts Institute of Technology

Richardson's first work on thermionic emission exemplified scientific research of a high order; coordinated analysis and experiment leading to an important generalization. Later as various workers studied coated or composite filaments for use as effective emitters in diverse types of apparatus there was research in applied science. As an example of engineering research in this same area there has since been a study of the behavior of emitters in gases, with a separation of the paths of electron and thermal flow, and the use of shields to inhibit the latter, to the end of greatly increasing the amount of emission per watt of loss, or per dollar of cost of power in the heater circuit.

There is a significant reason why engineering research has a place as a distinct kind of endeavor. This is apart from the fact that science cannot be expected to produce exactly those facts and relationships which are immediately applicable in engineering design. Rather it is because it takes a particular slant of mind, and a special background, to carry on research effectively with the economic factor as a prominent circumscribing restriction.

The greater part of engineering research has been carried on in the past in commercial organizations. While some such dignify with the name of research even crude empirical control of materials or processes, there are at the other extreme concerns which carry on scientific and engineering research of a high order. The commercial organization has, by its very nature, a point of view which is likely to be restricted. In the narrow sense it is responsible to its stockholders for a profit, and this leads to a restriction of its research to the immediately profitable. In a larger sense it is responsible to its employees for security against the fluctuations of employment consequent upon shortsightedness, and it is responsible to the public for the best possible ultimate development of the products or services it supplies. A recognition of this broader responsibility carries with it an appreciation of the value of research on a more comprehensive and farsighted basis. That the more mature and socially sound point of view has appeared at all in our capitalistic scheme is a reassuring fact which is worthy of greater emphasis than it receives. To my mind the American Telephone and Telegraph Company, with its recognition of its responsibility to its stockholders, its employees, and its subscribers, is outstanding. Wherever this advanced philosophy guides the management, will be found research laboratories in a highly developed state of advancement, for the interests of all in the proper progress of an industry can be safeguarded in no other way.

Industry, by and large, is not yet prepared for this enlightened vision. The ravages of unconfined competition, the sudden impact of technological advances upon units with a specialized product, the necessity for black figures if continuation is to be assumed for even a little while, prevent the advent of much altruism even when those in command are truly capable of such a broad outlook. Then too, much of our industrial life is still dominated by those who are incapable of dreaming dreams or seeing visions, beyond the dream of immediate profit or the vision of temporary advantage over a competitor.

As the advantages of high grade engineering research become apparent this situation provides an opportunity for its development in the scientific and technical institutions, particularly in the colleges of engineering and science. As such research becomes more scientific in its objectives, as it of necessity must, this opportunity is enhanced. Engineering research of the strongest form can be carried on effectively only in the presence of scientific research with which there can be interchange, and true scientific research finds its place most naturally and effectively in the academic atmosphere. The trend toward a greater amount and higher type of engineering research in academic institutions, which has been notable in recent years, is thus founded upon a basis of reason.

The gap between science and rule-of-thumb practice will remain wide in certain domains for some time to come, but it is noticeably and constantly narrowing in others. The replacement of empiricism by analysis and precise measurement goes on apace. Pyrometers supersede guessing at temperatures by sight, color analyzers reduce the matching of colors from a questionable art to a science, spectroscopy measures the trace of additive component the erratic effect of which was shrouded in mystery, and in many other ways men are able to precede on the basis of precise data where formerly they depended on estimates.

This trend toward analysis and precision in engineering affairs is forced by several conditions. With some products the cream of the market is skimmed; and it is now not sufficient to make simply a device that will operate, or a product that will catch the eye. The purchasing public is becoming intelligent, slowly and painfully to be sure, but nevertheless appreciably. Compare the advertisements of products of today with those of the gay nineties. True the power of reiteration of absurdities still remains, and the appeal of comedians will still boost the sale of antiseptics. But it is not maintained that the public is intelligent and unswayed by propaganda, simply that it is becoming so; and the trend is indubitably present. Refinements of design alone force more basic methods of attack. Consider the gas engine as an example. At first this was the result of individual unguided invention, produced in its operative form by empirical mechanics. As it progressed it gathered a surrounding fringe of analytical study, more or less casually regarded by those who really built engines. This is somewhat the situation at the moment. The trend toward making the gas engine the result of careful analytic examination is however evident. As the struggle goes on to build lighter, more reliable, more efficient internal combustion engines it becomes imperative that stresses be known, that the mechanism of flame propagation be understood, and that the conditions of deformation of parts and dynamic balance be analyzed. The manufacturer who can proceed most surely along this path will build the engines of tomorrow.

The trend in this country is marked, but there is no occasion for smugness. In this respect we have apparently lagged seriously behind Europe. This is a young country, and we do peculiar things in a slapdash manner. In fact our tendency to rush in an erratic way without due planning into all sorts of

experiments is the cause of much of our present bewilderment. Such an atmosphere is not conducive to analysis even in material things. Moreover much of our business is still dominated by those who fail to understand and who scorn the scientific method. That our automobiles should acquire four-wheel brakes, or independent springing, only after such things have been used for some time across the water may injure the pride of those who realize that such is the case; but it should not surprise us. Our automobile manufacturing companies are controlled in their policies rather generally by salesmen or organizers rather than by engineers. The greatest individual in the industry, while a wonderful organizer and promoter, and something of a comfort to those who lean heavily on rugged individualism, is after all primarily a technician in his background and with a mechanic's instincts. With all due respect to whose who are making advances in the field, it still appears that we have no true cause for satisfaction with the automobiles we drive; and it is probable that this situation will not be altered until the industry places its main reliance upon programs of engineering and research commensurate with the size of the industry and the opportunity which still lies before it.

There has been too much in this country of what may be called Christmas tree engineering. A product has a fault, so a gadget is added to correct it. But now the gadget develops a difficulty, so a second gadget is put on to remedy it. The continuation of this process produces something resembling a Christmas tree in the multiplicity of its complicated elements. This sort of thing is usually the result of exaggerated attention to the immediate at the expense of the basic.

Our disabilities and lameness cannot however be entirely blamed upon the industrialists. Scientists and engineers are partially responsible for our slow progress along the path of more reasoned design and production. In general they are too intent on their own interesting fields to enter or take an interest in others, and are mildly content to be let alone if not ignored. Lawyers, salesmen, merchants, and sometimes engineers become promoters and organizers of new enterprises. For a scientist to become a promoter is often to lose caste. The scientist or engineer in a large organization often fails to secure that comprehensive grasp of its ramifications, often fails to reach out for that larger responsibility for its acts, which are essential to rising to the direction of its affairs. Certainly if they do not insist on their share of direction they are not in a position to complain if the direction is faulty, or if the trend toward a more scientific attitude is not more marked.

The trend toward more of research in engineering, and of a more refined type of research, has brought a greater emphasis on graduate study in engineering. Unfortunately such study has only too often been held to connote simply a closer specialization, rather than a broader approach. Certainly we need the help of men who have highly specialized in their training and practice. It is also a successful adventure when a man, by reason of graduate study, becomes more of a scientist in his approach to engineering. But there are other ways in which the engineer needs to broaden his outlook. We need more good engi-

neers with a highly developed knowledge of economics, or with a training in law, or with facility in the social sciences, or with many another type of equipment. It is to be hoped that as the trend toward more of graduate study by engineers continues it may also become more diversified. There is certainly fully as great a need for broad training of those who enter the profession of engineering as for those who enter medicine or law, yet the traditional four-year course of the engineering schools has forced crowded curricula with little opportunity to give proper attention to those subjects which require unhurried contemplation for their true mastery. The rigor of undergraduate engineering study, with its inculcation of habits of diligence and precision, is marvelous training for a youngster. When it is combined with graduate study of a broader range of interest the result should be a group of men more admirably trained for a career in engineering in its best professional sense.

Other problems become prominent as engineering research becomes more basic and as it is more largely developed in the educational institutions. One problem thus emphasized is that of our patent system. Somewhat antiquated and cumbersome, this system has been almost overwhelmed by the growing complexity of its subject matter. Yet it has had a great deal to do with our rapid industrial progress in the past, and it is essential that it function smoothly if this progress is to continue unabated. By reason of their tendency to apply their findings directly to use, scientific men are involved with the system whether they realize it or not. Educational institutions carrying on research cannot ignore it without failure to perform a complete function. Adaptation of and to the system is a major problem facing scientific and engineering men and institutions. The common failure in this country to realize the imperative nature of this problem is caused by a general lack of appreciation of the nature and purpose of the patent system.

There is a common fallacy that the patent system was set up for the sole purpose of rewarding inventors. Rather it was created for the purpose of bringing inventions to fruition for the benefit of the public, by rendering it possible for a manufacturer to undertake the initial cost necessary to develop an idea into a finished product and to introduce a new and untried combination to skeptical purchasers. As soon as the reward aspect of the patent system is abandoned, it becomes much more reasonable to consider the pooling of patent rights in an organization for the use of the organization rather than the individual.

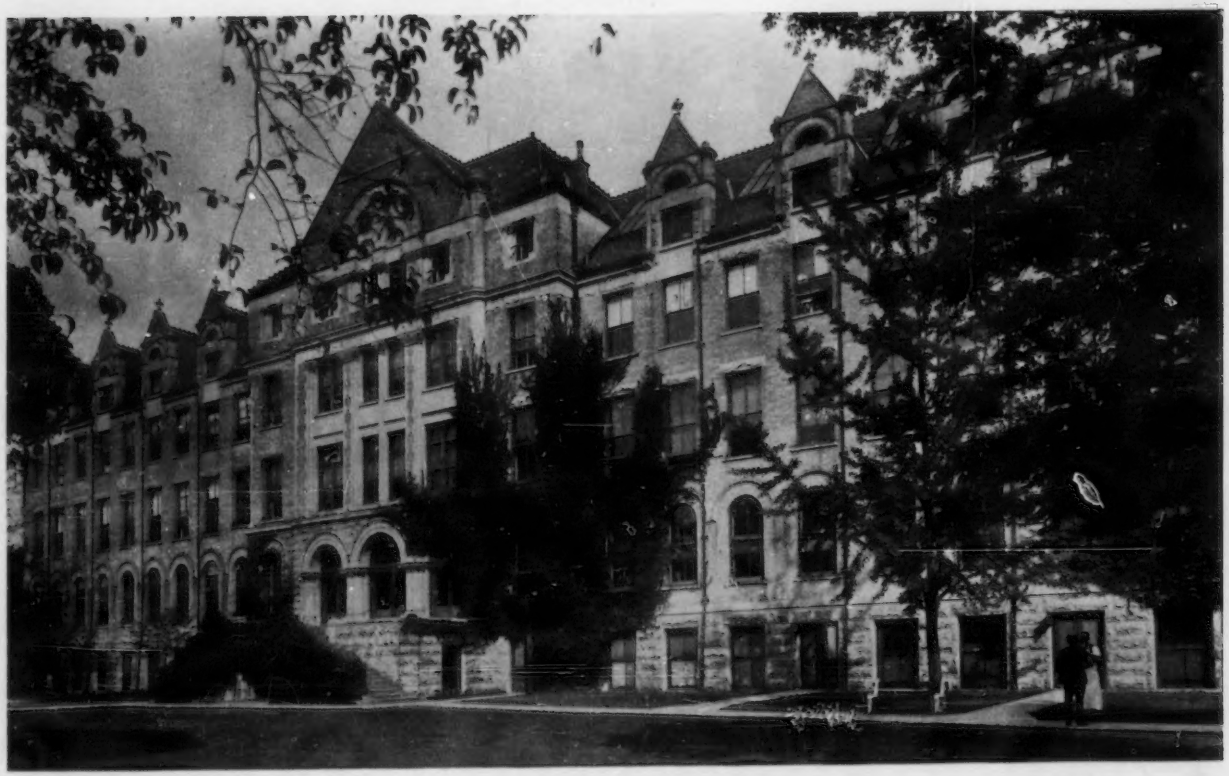
The scientific man, who makes an invention, does not discharge his full duty by simply publishing his results, although he often thinks he does. Failure to patent a truly important invention prevents the system provided for the purpose from functioning to enable the public to secure the results of that invention for its use. It may come into use anyway, but if its preparation for market involves serious expense the chances are that it will be completely lost. Sometimes simple publication does not produce this result merely because publication by one man is in itself no bar to patenting by another of the same idea, unless indeed the second individual unduly delays his application for patent.

Monopolistic control through patents is capable of having a benign influence when exerted by organizations dedicated to the public interest. This has been demonstrated especially in the case of certain inventions in the medical field, where control has been exerted for the maintenance of proper quality and reasonable price to the users. There are many other aspects of this whole matter which are beyond the scope of this paper, and which are conveniently summarized in the recent report of a committee of the American Association for the Advancement of Science. The important point here is that the present trend in engineering research is forcing attention to this matter, and that the proper consideration of it has been clouded by a great deal of misunderstanding and misapprehension.

The interlinkage between industry and the educational institutions is intensified by the present trend. In fact self-sufficiency, which some time ago went out of fashion among scientists, is recognized as being a provincial attitude even for organizations. The sudden advent of revolutionary scientific concepts and discoveries from hitherto unappreciated sources has rendered all workers in scientific sectors chary of the thought that no good can come out of Nazareth. The university investigator is no longer regarded as outside the pale by industrial groups, nor is the academic atmosphere longer regarded as too refined for the scientific worker who has industrial allegiance. This mutual respect is but one of the encouraging signs of the times.

Another is the refreshing ethical code which exists in regard to recognition of priority, and the generous attitude toward competitors which prevails among scientific and technical men generally. Of course we still have disputes and disagreements, and the contest has lost none of its keenness because it is conducted on a basis of greater emotional stability. To realize that there has been a change in atmosphere one has but to go back a hundred years and read a few scientific papers at random. The change is more than superficial, more than a gloss of etiquette. There are too many competent scientific minds at work today, and they are too necessarily forced into contact by the complex nature of their problems, for any individual to long retain a conviction of general superiority or infallibility. This trend is significant and encouraging. One can become really cheerful by speculating on the possibility of its extension into such a field as that of politics.

So, as I view the present trends I find them wholesome and reassuring. Engineering research is becoming recognized, and it is being conducted on a higher plane of accomplishment. The new appreciation of its potential possibilities is giving a needed impetus to graduate study, and a greater interdependence between industry and the educational institutions. There are problems of serious moment which are intensified by the development; but they have their opportunities as well as their dangers. The outlook is bright—if the storm passes.



RICHARDSON MEMORIAL BUILDING
School of Medicine, Tulane University
New Orleans, La.

THE HUMAN BODY'S DEFENSE AGAINST DISEASE*

PROFESSOR ERNEST CARROLL FAUST

Professor of Parasitology, Tulane University School of Medicine

INTRODUCTION

One medical lexicographer (Gould) defines disease as "a condition of the body marked by inharmonious action of one or more of the various organs, owing to abnormal condition or structural change." It is a departure from normal function or state of health, characterized by a train of symptoms. Abnormality of structures or functions may be hereditary, or may be due to prenatal influences or injury produced at birth. It may be caused by malnutrition, intemperance in food or drink, by lack of sleep or exercise, by overexertion, or it may be the natural sequence of old age. Again, disease may be the result of mechanical or chemical injuries of extrinsic origin such as those sustained in an automobile accident or in a factory, or by gas attack on the field of battle. If the shock is not too severe and the damage not too extensive or too acute, regeneration of the injured organ or member may take place and normal function again be restored. A third group of diseases is produced by parasites of various kinds, such as bacteria, spirochetes, filtrable viruses, fungi, protozoa, worms and arthropods. With such organisms and the dysfunctions which they produce we are more or less familiar. As examples, one may mention typhoid fever, pneumonia, syphilis, measles, athlete's foot, malaria, amebic enteritis, hookworm disease and scabies.

The several types of disease-producing agents are not always separable from one another. Frequently one may be the cause and another a contributing factor to the particular syndrome discovered. One may lower the body's threshold of resistance and allow the other to wreak havoc on the system. Or, one may more or less successfully inhibit the actions of the other.

All in all, probably the greatest amount of disease is due to parasites which attack the human body. In order to obtain a reasonable understanding of the injury produced by parasitic organisms, it is necessary to inquire into the following facts:

(1) The site of the parasite in the body. Is it localized in a certain level of the intestinal tract, the lungs, the blood-vessels or blood-forming organs, or is it disseminated throughout the body?

(2) The amount of the infection acquired by the host, either at one time or by cumulative effect.

(3) Is the organism capable of reproducing its kind in the human body? Do the products (daughter organisms, cysts, eggs, etc.) affect the body unfavorably?

(4) Is the particular strain of the organism relatively virulent or avirulent?

* Address delivered at the installation of the Tulane University Chapter of the Society of the Sigma Xi, New Orleans, La., April 13, 1934.

(5) Does it produce mechanical injury, such as destruction of tissues; is its damage due to the elaboration of toxic products which affect the body locally or generally, or is its danger due to a combination of mechanical and toxic factors? and

(6) Does the body, in attempting to localize the infection, produce excess tissue or a type of tissue which is harmful to its normal function?

Let us inquire briefly into some of these disease-producing factors in the case of the representative diseases mentioned. Typhoid is a bacterial infection, in which the bacteria are distributed to all parts of the body, but tend to become localized in certain foci, particularly in the lymphatics and the small bowel, in the wall of which the typhoid organism multiplies rapidly to produce inflammation and destruction of the tissue. Usually there are signs and symptoms indicative of a generalized bacteremia. On the other hand the cocci which produce pneumonia are usually localized in the alveoli and bronchioles of the lungs, where they multiply and provoke inflammation and consolidation of the tissues. In pneumonia the strain or type of the organism governs to a considerable degree the severity of the symptoms. In syphilis, although the spirochete involved produces a typical local lesion, it becomes disseminated almost immediately throughout the body *via* the lymph channels and in its third stage may involve practically every organ and tissue, including the central nervous system. Measles is probably produced by an ultra-microscopic virus, which is implanted in the mucous membranes of the nares, where it multiplies and later becomes more or less generalized, but with catarrh of the mucous membranes and a characteristic enanthem and later exanthem of the skin. Athlete's foot is a fungus infection which grows only in the deeper layers of the skin. The plasmodium of malaria is a one-celled animal parasite, which is introduced through the skin into the peripheral blood as a result of puncture by an infected female anopheline mosquito. The organism lives within red blood cells which it destroys. It multiplies asexually in the blood stream and in blood-forming organs, such as the spleen. The pathogenic ameba is a one-celled tissue parasite primarily of the wall of the large bowel, where it multiplies and destroys the tissue. Its injury is primarily local; in uncomplicated cases systemic reaction is usually slight compared with the local effects. The hookworm is a parasitic worm about the size of a small pin. It lives attached to the wall of the small bowel, from which it obtains its nourishment and on which it inflicts injury, so as to produce hemorrhage and ulceration. It does not multiply in the bowel. In addition to local injury the toxic by-products of the worm are absorbed into the system. The clinical picture of hookworm disease is, therefore, due to a combination of local mechanical and generalized toxic factors. Scabies is a skin infection with a species of mite (*Sarcoptes scabiei*), which tunnels in the skin layers. Here the female mite lays eggs which hatch and live in the same tunnels or, as a result of the patient's scratching, are introduced into new sites, and spread the infection. It is readily communicable from one person to another.

These and other elemental facts have become common knowledge as the results of tremendous labor on the part of scientific men, who have sacrificed time and effort, and occasionally have lost their lives, in attempts to elucidate the etiology of disease and pathogenicity of the disease-producing organisms.

This information, either as a whole or in part, has made possible man's fight against disease. Thus he has erected artificial barriers to prevent the organisms from reaching the human body. Public health officials have waged an ever-increasing war against human disease in reservoir and intermediate hosts. They have quarantined sick individuals and have provided means for sterilization of the human exudates and fomites. They have also fought these organisms in man himself, by utilizing specific chemotherapeutic agents, and by vaccines and serum therapy have immunized or partially immunized the body against certain diseases. The reduction in morbidity and mortality from smallpox and from diphtheria alone is a brilliant commentary to these latter efforts. Most of these methods are, however, entirely artificial and extrinsic, and do not ordinarily take into consideration the fight which the human body itself makes against disease. It is our purpose tonight to inquire briefly into the body's own defense mechanism and to cite a few examples of its success or failure.

THE BODY'S OWN FIGHT AGAINST DISEASE

Disease has previously been defined in general terms. More technically, when it is caused by a parasite invading the body, it is the result of the degree of adaptation of the parasite to its host, in other words, of the host-parasite relationship. The human body is literally surrounded by potentially pathogenic organisms. These organisms are present in the air we breathe, in the water we drink, in the food we eat, and the clothes we wear. Even with the most assiduous and elaborate personal care we cannot avoid such contact. To many of these parasites, man, as a distinct species of animal, inherits a non-compatibility, whereas other animals are susceptible. Thus man does not develop Texas cattle fever, although in endemic foci he has undoubtedly been exposed on innumerable occasions. On the other hand, man is susceptible to bovine tuberculosis. Likewise, there is no proof that man acquires *Ascaris* from the pig, or the dwarf tapeworm from the rat, although he is readily infected with human varieties of these worms which are morphologically indistinguishable from those commonly found in the pig and the rat.

The unbroken skin with its secretions and the normal mucous membranes of the mouth and the respiratory tract serve as an effective barrier against many pathogens which commonly come in contact with these layers of the body. If the skin is broken or the mucous membranes irritated or the normal secretions temporarily in abeyance, the organisms may gain entry and disease may result.

Races of human kind or groups of individuals long exposed to certain infections, acquire a partial immunity to them. Thus the white man is less susceptible to tuberculosis than the colored races, and cases of amebiasis and

yellow fever occurring in communities where these diseases have long been endemic have relatively little clinical evidence of infection. However, newcomers to these areas are frequently highly susceptible. The same holds true for diphtheria and infantile paralysis in large centers of population, where many times the number of persons manifestly ill with these infections have been exposed or actually harbor the organism in their bodies. Individuals who maintain an equilibrium with the parasite without evidence of disease are known as *carriers*. Unless they are subject to physical or mental stress and strain, which reduce their resistance, they may never exhibit symptoms, although they are frequently the most important source of danger to other, more susceptible individuals.

Age also confers a relative immunity on the individual. While the newly-born infant usually is resistant to attack by the organisms of typhoid fever, diphtheria and measles, by virtue of the protective serum transferred to the fetus from the mother, children as a rule are less immune to most infections than are adults. Bacillary dysentery, malaria, infantile paralysis, dwarf tapeworm infection and ringworm are notable examples. Thus individual immunity tends to repeat species and racial immunity.

It is necessary that certain pathogenic organisms reach certain sites in the body before they produce fulminating infections. The cholera vibrio when introduced into the digestive tract produces the typical syndrome, but if injected subcutaneously it causes only a temporary local inflammation. On the other hand, the organism of tetanus, when swallowed, lives as a saphrophyte in the intestinal canal and frequently confers lasting immunity on the individual. If, however, it is injected subcutaneously or is introduced into a skin lesion under anaërobic conditions, it will produce the typical syndrome of tetanus, unless the individual is protected by autogenous or exogenous vaccine. Plague organisms, introduced into the skin, produce bubonic plague; if taken into the respiratory tract, they cause the pneumonic type of the disease.

If the potentially pathogenic organism actually gains entrance to the body tissues, what kind of mechanism operates to combat the infection? Authorities are agreed that two modes of attack are available, the antibodies elaborated in the system and the phagocytic action of certain cells. The first is usually referred to as a humoral response, and the second, as a cellular or phagocytic reaction. From the days of Ehrlich and his "side-chain theory" it has been assumed that toxins, introduced into the body, stimulate the development of antibodies, which, in turn, make certain cells of the body receptive for these toxins. In this way the toxins are not only neutralized but frequently there is produced an excess of receptors which become free in the body fluids and more or less protect the organism against future attack. The bacteriologists in particular have used this conception to explain many of the results of their experimental and clinical studies. Up to recent years the entire structure of host immunity has been built around this theory. It is well known that polymorphonuclear leukocytes rush to attack many types of invading microorganisms, either engulfing them or surrounding them by a more or less perfect

barrier. Such a reaction may result in abscesses or pustules. Less rapid in response are the monocytes or wandering cells, which constitute the second line of defense. They are the less mobile heavy artillery. In this connection it is interesting to note that pyogenic bacteria provoke a polymorphonuclear leukocyte defense, followed by a monocytic infiltration; that protozoan infections of the blood stream, such as malaria and the hemoflagellates, and the spirochete of syphilis, are dependent for the most part on the monocytic reaction, and that the pathogenic ameba, *Endamoeba histolytica*, unless accompanied by bacteria, stimulates little or no local cellular reaction.

For the past ten years Taliaferro (1934) and his associates have been conducting immunological studies on the protozoa of the blood stream, which permit direct observation as regards (1) the host response to infection and (2) the effect of the host's response on the invading organism. Two types of reaction have been observed, namely parasiticidal and inhibitory. In their studies on malaria they have not been able to correlate the parasiticidal reaction with antibody formation but "only with direct phagocytosis of the parasites by the differentiated macrophages." More recently Kahn (1934) has declared that the older conceptions of immunity are inadequate to explain the defense of the body against bacteria and foreign proteins; that the cells of the skin, muscles and brain, as well as the blood stream, protect the body against harmful invaders, but that the skin is tenfold as protective as are the other tissue elements. This special property of the skin is explained as a logical development, since this encasing layer of the body is the one which ordinarily contacts the invader first and in greatest amounts. Arnold and Bart (1934) believe that the keratin is the particular skin component responsible for this protection. Thus the newer conception tends to minimize the value of antibodies *per se* and to emphasize the importance of the cell as the armanentarium *par excellence* for defense.

Having outlined the basic principles which are at work in the body's own fight against disease, it now seems advantageous to illustrate how this mechanism actually operates in certain infections. Instead of citing the usual time-worn bacterial infections and filtrable viruses, the speaker has chosen his examples for the most part from the field of protozoology and helminthology.

1. *Amebic infection.* Although there are several amebae parasitic in the intestinal tract of man, only one of these, *Endamoeba histolytica*, is a proved pathogen. It invades the tissues of the large bowel by means of lytic and mechanical action, producing discrete lesions, which, in uncomplicated cases, provoke no phagocytic response. If this organism gains access to other sites in the body, as, for instance, the liver, similar non-inflammatory destruction of the tissue takes place. There is, nevertheless, a systemic reaction, as indicated by specific complement-fixation of the patient's blood. In highly susceptible individuals, whether otherwise healthy or with a low resistance, acute intestinal disturbance results from an appreciable destruction of the large bowel wall, with manifestations of protean character, including dysentery, diarrhea with or without constipation, tenesmus, loss of appetite, loss of

weight, nervous symptoms and a general run-down condition. In most parts of the world, however, for every case of acute infection with this organism there are many persons who are essentially "symptomless carriers." In these individuals the tissue destruction is being constantly compensated by tissue repair. In such persons the amebae are in equilibrium with their host. This group of carriers is relatively large in New-Orleans (4 to 20 percent of the population, depending on the group surveyed), but the most striking example to the speaker's knowledge is a native village in Panama, where children between six and fifteen years of age showed on examination by the speaker in 1930 an incidence of 90 percent, with no detectable symptoms. The only clinical case of amebiasis in the village was an old woman of more than ninety years. Senescence had apparently broken down her tolerance. Foreigners who have come in contact with this strain of ameba, have almost invariably developed an acute amebic dysentery. In the native population gross contact with the organism had occurred since early childhood. As a result a relatively high degree of immunity has been developed in the group.

Dobell and others have found that strains of the pathogenic ameba, if cultured in the test tube, are frequently difficult to plant in laboratory animals. Meleney and Frye (1933) have recently found what appears to be a difference in virulence in different strains of the organism. Amebae from a heavily infected hill population in Central Tennessee, when inoculated into kittens, produced a low grade pathogenicity, whereas the same species of organism, from an area in Western Tennessee with lower incidence, produced an appreciably higher degree of tissue destruction in experimental kittens. While the information is thus far incomplete, it points not only to the development of considerable tolerance to the infection in isolated communities, where individuals are heavily parasitized from early childhood by this organism, but also to a difference in the virulence of different strains. These conclusions are borne out by epidemiologic as well as by experimental data.

2. *Malaria.* Malaria in man is ordinarly caused by infection with one or more of three human species of *Plasmodium*. Closely related but specifically different plasmodia occur in Old and New World monkeys. The disease in man is usually treated extrinsically by administration of quinine or other drugs. Several years ago (1925) Yorke suggested that malaricidal drugs by themselves seldom, if ever, produce complete cure. In the tropics and other highly malarious areas, exposure occurs early in childhood and the individual becomes gradually resistant to the pathogenicity of the organism. In isolated communities a single (homologous) strain of each species tends to predominate, and manifestations of the infection become less common as the individual matures. So-called "spontaneous recovery" frequently occurs. If, however, another (heterologous) strain of the same species is introduced into the community from some other area, it may produce an epidemic, since the population has not acquired a tolerance to it. Tertian malaria in a non-immune adult person is characterized by an incubation period of about two weeks, followed by a series of chills and fever, typically every forty-eight hours. These attacks

usually subside after about three months and the patient may be completely cured of the infection if his defense mechanism is good, or, there may be a period of about three months remission followed by a relapse, in which the symptoms are rarely as severe as in the first attack. Theoretically, and frequently in practice, such cases are eventually self-cured of the disease. Administration of malaricidal drugs, while humanely and economically desirable, is biologically wrong, since these drugs prevent the body from developing its own defense. Ideally they should be usued only when the life of the patient is endangered.

3. *Relapsing fever.* This disease is produced by a spirochete introduced into the human body by crushing an infected louse on the skin or by skin puncture effected by an infected tick. As is the case in malaria, there is a prepatent period, followed by a febrile paroxysm, which, in this infection, may last for three or four days, after which the fever subsides and the disease may be self-terminating; or a second and even a third attack may follow, each less intense than the initial one. Specific chemotherapeusis is biologically indicated only in serious cases. African natives who have become somewhat tolerant to the virulent tick-borne type of the disease, have within the past decade and a half been brought in contact with the milder louse-borne type of Europe and Asia, with the result that severe epidemics have broken out among them. This is another illustration of resistance to a homologous strain, which does not confer tolerance to a heterologous strain of the same parasite.

4. *Kala-azar and Chagas' disease.* These diseases are caused by protozoa known as hemoflagellates, which are found in the blood stream. The agents of African sleeping sickness belong to the same group. In the circulating blood or in the tissues the organisms are rapidly attacked by the macrophage white cells, but the parasites have become so adapted to the engulfing cells that they not only survive but multiply rapidly within these cells. This provokes a considerable increase in the production of macrophages which, in turn, become the incubators of more parasites. Reservoirs of these cells, such as the spleen, the bone marrow and the lymph nodes, become greatly congested, the polymorphonuclear leukocytes are greatly reduced in numbers, and the patient becomes non-resistant to secondary invaders of the intestinal tract, the lungs and other centers of the body. In this instance the cellular reaction is rapid and quantitatively sufficient, but the parasiticidal mechanism is relatively ineffectual. However, there is evidence of the development of considerable age tolerance, since these two diseases are primarily those of childhood and are much less common in adult individuals.

5. *Ascaris.* This is the common large intestinal roundworm which has world-wide distribution. It is primarily an infection of childhood, due, no doubt, to the fact that children are more likely to contaminate themselves with polluted soil containing the embryonated eggs rather than because of any proved age resistance to this human parasite. Some children appear to have little ill effects from harboring dozens or even hundreds of these worms; other children, as well as some adults, are very sensitive to infection with a

single worm. Digestive upsets, either caused by the worms or otherwise, provoke the worms to unusual activity, so that by their wanderings into unaccustomed sites, they may cause serious damage. Sensitized patients may exhibit asthma and various nervous disorders. Some children in heavily infested foci are continual reservoirs of various developing stages of the organism, as well as the adult worms. In contrast, puppies, which are either born with a related ascarid infection or acquire it early, freqently succumb to the infection, but if they survive they are highly resistant to subsequent infection.

6. *Hookworms.* These small worms live in the small bowel, with their heads anchored to the intestinal wall. Here they feed and produce open wounds, pumping blood from the tissues of the host far in excess of their own food needs. Their toxins are also absorbed by the system. The loss of blood from the intestinal wall, together with the effect of the toxins on the blood-forming organs of the patient's body, produce the profound anemia which is characteristic of severe hookworm disease. In addition to the two common human hookworms of the New and Old Worlds (*Necator americanus* and *Ancylostoma duodenale*), there is a third species (*Ancylostoma braziliense*) which occurs in man, dogs and cats in warm climates. In dogs and cats, and in man in strictly tropical areas, the worms migrate normally from the skin through the body tissues to the site of their adult predilection in the intestinal tract. In man along the coast of the Southern United States they penetrate as infective-stage larvae into the deeper layers of the skin but, apparently unable to migrate to the intestine, continue to wander for weeks and even months in serpiginous tunnels in the skin, producing the clinical picture of "creeping eruption." After an initial infection with hookworms, dogs are known to build up a relatively good resistance to subsequent infection. While similar controlled data are not available for man, there is reason to believe that the same mechanism obtains in human infection.

7. *Trichinella infection.* Infection by this minute roundworm is acquired by eating raw or inadequately cooked pork flesh infested with encysted larvae of the parasite. There is an early intestinal phase of the disease which closely resembles food poisoning. This is followed by the deposition of larvae on the part of the mother worms into the intestinal lymph channels or mesenteric veins and the migration of the larvae to striped muscle. This second phase is accompanied by excruciating muscular pain. During the third period the larvae become encapsulated in the muscles. They are literally sealed within their own sarcophagi. Symptoms during and following this third stage of the infection are referable to the toxins produced by the larvae before encystment, and may cause death or prolonged invalidism.

Trichinosis has always been a serious public health problem in Germany and other pork-eating countries of Europe. Within recent years the number of clinical cases diagnosed in the United States has been on the increase. For the year 1933 a total of 300 cases was reported to the United States Public Health Service. Of this number nearly half originated in New York

State. However, these reported clinical cases apparently constitute only a very small portion of the human beings actually infested with this parasite. Routine autopsies in Rochester, New York, for 1931 indicated an incidence of 17.5 percent of the population and recent routine autopsy findings in Boston show a 27.6 percent incidence. These figures demonstrate a tremendous increase in human exposure since 1898, when Osler published his data on 1,000 autopsies in Baltimore, with only 0.6 percent infection. The experimental work of McCoy (1933) suggests that light, subclinical inoculations practically immunize the experimental host against subsequent heavy doses of the parasite. Bachman and Rodriguez-Molina (1933) explain this resistance to hyperinfection on the basis of antibody formation and local mobilization of phagocytic white cells of the body in the intestinal wall of the host, thus effectively blocking subsequent invasions of the parasite into the body tissues. These groups of data, when analyzed, suggest that a large percentage of our population, particularly in the Northeastern United States, are unknowingly but successfully vaccinating themselves against mass infection of this parasite.

8. *Disease-producing organisms which provoke tissue reaction detrimental to the host.* Certain parasites of the human body, once they have reached the site of their predilection, by means of their mechanical and toxic action, irritate the host tissue to such a degree as to stimulate the rapid infiltration into and proliferation of tissue cells immediately around the worms and their progeny. While this mechanism protects the body as a whole, it frequently leads to the development of fibrous nodules within vital organs, such as the liver, the urinary bladder and lymph channels, not only at the expense of vital tissues, but frequently obstructing in part or as a whole the normal circulation of body fluids. Thus in blood-fluke infections which are very common throughout tropical and Oriental countries, cirrhosis of the liver or fibrosis and calcification of the bladder wall result from this excessive tissue response, while in Bancroft's filarial infection, blockage of the lymph flow produces elephantiasis and related signs and symptoms. Furthermore, the tissue reaction may proceed beyond limits of body control and terminate in neoplasms or cancerous growths. In this group of infections the mechanism, which was designed to protect the body, actually produces more harm than good. Biologically considered, this protective mechanism will some day have to be discarded.

DISCUSSION

Thus far we have seen that the combat against the diseases of man depends on artificial or extrinsic factors on the one hand and natural or intrinsic factors on the other. The human body, with its complex machinery for life, growth and reproduction, is, on final analysis, primarily responsible for its own well-being. Like all organisms, many of its tissues are provided with a mechanism for regenerating, at least in part, injured and damaged members. It has also through the millenia developed methods of attack against parasite invaders. In some cases the adjustment is sufficiently perfect so that the parasite can live commensally in the body without harm to the host: under such

circumstances the body's tissues are not injured by the parasite. In other cases certain groups of the population have been so long in contact with the pathogenic organism that the damage produced by it is not usually of clinical significance: persons living in such an equilibrium with the parasite are *carriers*. Other groups of the population, who have not had this host-parasite experience, may be highly susceptible to the infection. Against other parasites the body develops immune substances, which, either directly or by stimulating the white cells to increased phagocytosis, control the effects of the parasite, and, at times, provide against future attacks by this species of parasite. Such immunity tends to increase with age, as well as with racial or group contact with the infection. Some host tissue responses, intended as beneficial, are actually detrimental to the body.

The increased tendency to provide artificial barriers against disease are prompted by humane and economic motives but are opposed to biological law, namely, that the body must perfect its own natural mechanism of defense. In civilized countries scientists, including medical men, as well as laymen, are nowadays reared under the aegis and protecting wing of public health. When they are placed in a non-protected environment, such as the tropics or the Orient, they are usually as helpless as newly-born infants. In primitive human society, as in the animal world, the survival of the fittest individuals obtains. In modern society humanitarianism has cared for the weak and disabled, and many of us would not be here had not such artificial assistance been provided. It is possibly debatable whether this artificial protection has done more harm than good.

Epidemics and epizootics have at times decimated man and the lower animals. At such times the strong and the weak alike have succumbed, and civilizations have been nearly extinguished. Plague in India, typhus fever in Europe and Asia, malaria in Italy and yellow fever in the United States are notable examples of such scourges. Public health measures to guard against recurrences of these ravages constitute one of the high points of modern civilization. Yet in endemic foci these same diseases exist today in mild form and the native populations are gradually acquiring immunity or tolerance to them. For such populations fear of epidemics is greatly minimized.

Without any disparagement of the splendid endeavors of men who have risked their lives to protect their fellows from disease, it is time we pause to consider the final results of artificial protection alone, without the fight which the body as a mechanism is prepared to wage against parasite invaders. It is obvious that natural and acquired resistance and immunity are by far the more important to the human race. Let us recognize the interdependence and relative values of both types of defense, and by rational as well as altruistic programs perpetuate the race as well as the individual. By so doing we can more surely guarantee a continuity on a higher plane of the contributions which are constantly being made to human knowledge and happiness.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF SIGMA XI

Washington—April 29, 1934

The first meeting of the Executive Committee for 1934 was held at the Cosmos Club, Washington, D. C., April 29, 1934. The meeting was called to order at 10.00 A.M. by President Parker. Those present were: President Parker, Retiring President Wilson, Secretary Ellery, Treasurer Pegram, Professor Cole, Professor Leuschner, Professor True, Professor Stadler, Mr. Davies, Mr. Knight, and, during part of the meeting by invitation, Prof. Henry B. Ward. Business was transacted as follows:

1. REPORT OF INSTALLATIONS:

a. President Parker reported the installation of the chapter at the Massachusetts Institute of Technology April 5 (see page 43, this issue).

b. Secretary Ellery reported the installation of the chapter at Tulane University April 13 (see page 44, this issue).

2. REPORTS OF OFFICIAL VISITORS:

a. Wesleyan.

At the meeting of the Executive Committee December 28, President Wilson appointed Professor Pegram and Professor Baitsell as official visitors to Wesleyan University. The visitors submitted a report from which the following excerpts are made:

1. Wesleyan University is distinctly an undergraduate college offering beyond the Bachelor's degree only work for the Master's degree. It is the intention of the Institution according to statements made by the President to us to keep itself an Institution of about 800 students and so far as can now be foreseen, not to develop professional schools or a graduate school.

2. For an undergraduate college the Institution gives an unusually large amount of attention to work in scientific subjects. Its departments are well manned and do their work in laboratories which in the main are modern, well designed, and adequate for undergraduate work and for the research of the staff. There are two quite new laboratories, namely the Hall Laboratory of Chemistry, built in 1927, and the Biological laboratory, built still more recently. Physics is housed in a somewhat older building, which is, however, a good laboratory. Geology is in an older building. Astronomy is admirably provided for in the Van Vleck observatory. Psychology has at present limited space in one of the older buildings.

3. There is definite attention to research by the staff and the students who stay on for a year or more, after their Bachelor's degree, as assistants.

4. The institution gives definite aid to scientific research. Special funds for research represent an investment of $341,000. Furthermore the college is just receiving a gift of a $1,000,000 or more without any specifications as to its use and the president told us that one of the three things that he wishes to do with this fund is to give increased support to research.

There is a standing faculty committee on research and from our talk with the president we judge that he regards it as a natural and necessary part of a properly conducted college that the staff and the advanced students have opportunity and means to engage effectively in the advancement of science. There seems every reason to believe that Wesleyan will go forward in this direction rather than stand still.

5. The scientific members of the staff and the interested students already have made for themselves certain opportunities for coming together to hear about and to discuss scientific developments. There is the Middletown Scientific Association, founded in 1871. There is the Atwater Club in chemistry, the Van Vleck Club in mathematics, and perhaps most important, there are the meetings of what is termed the Scientific Division of the Faculty, representing mathematics and the natural sciences. The Scientific Division meets several times a year to discuss scientific matters and to hear lectures by visitors.

Respectfully submitted,

GEORGE A. BAITSELL,
GEORGE B. PEGRAM.

The following resolution was adopted:

In view of the favorable letters from Dean Mayo of the graduate school of Harvard University, President Conant of Harvard University, Prof. Gary M. Calkins of Columbia University, Prof. L. C. Dunn of Columbia University, and Dean Furniss of the graduate school of Yale University; also of the long interest in scientific work at Wesleyan; also of the steady output of research on the part of members of the Wesleyan faculty; also of the definitely stated policy of the administration of Wesleyan to maintain the undergraduate character of the institution, and to continue preparing students for graduate work in universities; the group of petitioners at Wesleyan University is requested to present a formal petition for a charter for a chapter of Sigma Xi at the next meeting of the Executive Committee.

b. Den er.

After considerable discussion it was

Voted—a. To take no further action at this time on the petition of the University of Denver.

b. That the secretary be directed to send a letter of encouragement to the Sigma Xi Club at the institution, and to the president of the university.

3. UNIVERSITY OF BUFFALO:

At the meeting of the Executive Committee held December 28, consideration was given to the conditions at the University of Buffalo. Since the meeting Dean Richtmyer of Cornell and Professor Pegram have been at the university and both expressed the opinion that the next step in the procedure in connection with petitions for chapters might safely be taken at this time. It was therefore

Voted.—That the president be authorized to name official visitors to the University of Buffalo.

(Subsequent to the meeting President Parker appointed Prof. Russell T. Wilkins of the University of Rochester as the official visitor.)

4. UNIVERSITY OF FLORIDA:

Information supplementary to that which had been presented to the Executive Committee at previous meetings regarding the University of Florida was presented by the secretary and given full consideration. Mr. Knight of the Alumni Committee commented favorably upon the conditions at the university, basing his remarks upon information he had had in person regarding the institution. After considerable discussion it was

Voted.—That an official visitor be appointed to make a survey of conditions at the University of Florida for report at the next meeting of the Committee.

(Subsequent to the meeting President Parker appointed Prof. Joseph K. Roberts of the University of Virginia as the official visitor.)

5. CARLETON COLLEGE:

The secretary reported that Carleton College had petitioned the Executive Committee several years ago for a charter for a chapter. At that time the Committee was not prepared to take any definite action. A Sigma Xi Club has been active at Carleton ever since the presentation of the preliminary request for a charter. Doctor Wilson and Professor Cole stated that in their opinion the situation at Carleton was similar to that at Wesleyan. It was

Voted.—That the president appoint an official visitor to make a survey of conditions at Carleton College for report to the Executive Committee at its next meeting.

(Subsequent to the meeting President Parker appointed Prof. R. A. Gortner of the University of Minnesota as the official visitor.)

6. SMITH COLLEGE:

At the December, 1933 meeting of the Executive Committee, Professor Mather of Harvard and Professor Dunn of Columbia, official visitors previously appointed by Doctor Wilson to make a survey of conditions at Smith College, submitted their report. At that time Professor Mather and the secretary were asked to ascertain what the probable relations would be between the existing Science Club at Smith and the Sigma Xi Chapter if one were

established. The secretary presented a letter from Prof. Howard M. Parshley, stating that the Science Club at Smith holds occasional meetings and that probably these would continue; and further that in the opinion of the writer a chapter of Sigma Xi would find ample opportunity for usefulness at Smith. The secretary also presented a letter from President Neilson stating that the establishment of a chapter of Sigma Xi at Smith would be an encouragement and stimulus to scientific research among the faculty and advanced students in the college, and expressing the support of the administration of the petition for the chapter. In view of these letters and of the report of the official visitors, it was

Voted.—That the petitioners at Smith College be requested to present a formal petition for a charter for a chapter to the next meeting of the Executive Committee.

7. Certificates of Award in Commendation of Research:

The secretary called attention to the award of certificates of commendation of research by students in institutions where there are no chapters of Sigma Xi, and asked whether in the judgment of the Committee it was wise to continue this activity of the society. Various opinions and comments were made by members of the Committee, and the consensus of judgment was that this part of the work of Sigma Xi is valuable and should be maintained. It was

Voted.—That institutions where there is no chapter of Sigma Xi should be invited to submit the records and theses of not more than three students from each of the fields of chemistry, physics and biology; and that these theses and records should be judged by a committee to be appointed later by the president.

8. Adult Education:

Professor Ward, permanent secretary of the A. A. A. S., presented some suggestions from the Association regarding activity on the part of the Association in adult education in a limited number of cities, especially along the lines of science. Professor Ward raised a question of whether in case the Association should undertake such a movement as this Sigma Xi would be interested to cooperate. Following Professor Ward's talk the Committee discussed the proposed project with a great deal of interest. It was

Voted.—That Sigma Xi should take a sympathetic and cooperative attitude in all efforts looking toward the expansion of general education in science, always keeping in view the purpose of Sigma Xi in the promotion of research.

9. Budget:

The treasurer called attention to the treasurer's report as printed in the March, 1934 issue of the Quarterly, and suggested that the budget for the current year be the same as for 1933. In connection with this discussion Mr. Davies of the Alumni Committee brought up the matter of the circularization of Sigma Xi alumni in support of the Alumni Research Fund. The secretary

called attention to the fact that in order to reduce expenses the alumni circularization in 1933 was carried out by inserting in the September, 1933 issue of the QUARTERLY blue slips requesting contributions to the Research Fund. The secretary also reported that the returns thus far had amounted to $438.05. The Committee was agreed that a more decided effort should be made to secure increased contributions. It was therefore

Voted.—That the budget for 1934 should be as follows:

Secretary's office, salaries and expenses	$4,100
Treasurer's office	200
QUARTERLY	2,500
Officers' travel expenses	1,200
Engraving charters	100
Circularizing the alumni	400
Total	$8,500

10. THE ALUMNI RESEARCH FUND:

Following the decision of the Committee regarding the budget for the current year, it was

Voted.—That the Alumni Committee be requested to formulate a letter to be sent to all Sigma Xi alumni members and associates, requesting contributions to the Research Fund of the society.

11. ALUMNI CHAPTERS:

At the December, 1933 meeting of the Executive Committee it was voted that institutions where there are Sigma Xi clubs, and other institutions in which a Sigma Xi club might possibly be organized, should become the nucleus of alumni groups in the immediate vicinity of the institution. In response to that suggestion a number of clubs had submitted proposals to the Executive Committee that they be permitted to organize an alumni chapter. These letters were read to the Committee. After considerable discussion it was

Voted.—To refer them to the Alumni Committee for report at the next meeting of the Executive Committee.

12. EMBLEMS FOR CANADIAN MEMBERS AND ASSOCIATES:

The secretary presented a letter from the McGill Chapter complaining that Canadian members and associates, when purchasing keys through the offce of the National Secretary, have to pay not only the regular cost of the emblem and the United States sales tax, but also have to meet the cost of exchange, Canadian customs duty, and Canadian sales tax. The McGill Chapter made request that an official Canadian jeweler be appointed with authority to manufacture Sigma Xi emblems for Canadian members and associates. It was

Voted.—To refer the matter to the National Secretary, with power.

13. USE OF ROMAN NUMERALS ON THE QUARTERLY:

A letter was read from Alfred L. Robert, medical librarian of Columbia University, in which the writer asked that the use of Roman numerals in the SIGMA XI QUARTERLY be abandoned, and that Arabic numerals be substituted. The writer stated that over 100 scientific journals and other publications had already agreed to discard the Roman letters. It was

Voted.—To authorize the secretary to use Arabic numerals instead of Roman numerals in the official publications of the society.

14. THE 1934 CONVENTION:

A letter from Professor Ward, permanent secretary of the A. A. A. S., was read, in which request was made for early action on the part of the Executive Committee of Sigma Xi in the choice of a lecturer for the joint meeting of the Association and Sigma Xi at the December meetings to be held in Pittsburgh. It was

Voted.—To ask President Parker to send an invitation to G. N. Lewis, University of California at Berkeley, to deliver the lecture at the Thirty-fifth Convention of the Society.

15. THE SEMI-CENTENNIAL PROGRAM:

The tentative suggestions made at the June, 1933 meeting of the Executive Committee regarding the program of the Semi-Centennial of the Society were presented to the Committee in full. The importance of the event and of the program was fully appreciated by the Committee. It was felt that time at this meeting was too limited to permit of proper consideration. It was

Voted.—That the President should appoint a special committee on program and appropriations for the Semi-Centennial, which is to be celebrated in Ithaca in June, 1936.

(Subsequent to the meeting President Parker appointed the following committee on Semi-Centennial Program and Appropriations: Pres. George Howard Parker, Sec. Edward Ellery, Treas. George B. Pegram, representing the Executive Committee: Mr. C. E. Davies, representing the Alumni; Dr. Willis R. Whitney, representing industrial research; Dean F. K. Richtmyer, representing the Cornell Chapter.)

16. ADJOURNMENT:

The Committee adjourned at 5.15 P.M.

EDWARD ELLERY, *Secretary.*

ROY LEE MOODIE (1880-1934)

AN APPRECIATION BY DR. OTTO F. KAMPMEIER
College of Medicine, University of Illinois

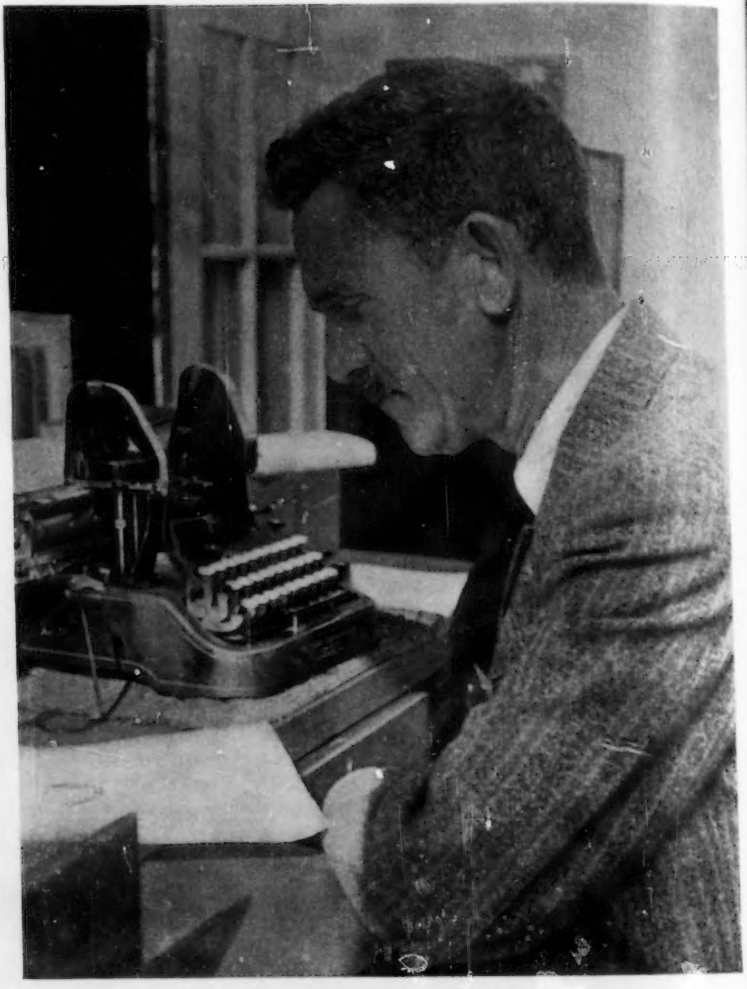
Roy Lee Moodie, who may be called virtually the father of the science of paleopathology, died at the age of fifty-four years on February 16 at the Hollywood Hospital, Los Angeles. This news has left a deep imprint on the minds of those who knew him and followed his work. The many letters addressed to him that still come from different parts of the world to his home bespeak the interest his work has aroused, and show that the apparent obscurity in which he lived and labored was not actual.

In part, Doctor Moodie was a Southerner. His father's people, of English and Welsh stock, were planters on the Virginia-North Carolina border. They moved on to Kentucky with their slaves when that state was being newly settled, and there acquired some of the finest tobacco land. The grandmother, a very capable lady, managed the plantation while her husband took the yearly cargo of tobacco down the Mississippi, to New Orleans. From these ancestors, Doctor Moodie inherited a strong love of the out-of-doors and a constitution which later carried him undaunted through the many years of ill health.

His mother's people, named Gregg, of Scotch and Scotch-Irish descent, hailed from Indiana, where the grandfather was the editor of an Abolitionist newspaper and took a prominent part in politics immediately preceding the Civil War. The four sons served in the Union Army and returned from the war with tuberculosis, which carried the family away save the two daughters. Sarah Gregg, the younger of these girls, upon her graduation from the Terre Haute Female College, went to Kentucky to teach school. There she met and married William Lemuel Moodie. They reared four sons and two daughters. Roy, the fourth child, was born on July 30, 1880, in Bowling Green.

Doctor Moodie's mother, though frail of body, was the center of the family life in the education of the children. From her, he derived a brilliant mind and the literary bent. The environment for the boys was her dominant motive in insisting that the family migrate from Kentucky to Kansas, where prohibition was being tried out. They came to Sumner County on the Oklahoma border in 1890, when Doctor Moodie was a boy of ten. Though the hard times immediately following wiped out their savings, the parents by dint of sacrifice and courage, with the strong assistance of the eldest daughter, Minnie, not only gave the children a sound, elementary training, but sent three of the sons through college at the University of Kansas. Doctor Moodie frequently mentioned with gratitude the help given him at that time by his sister, Miss Minnie Moodie, who formerly was secretary to William Allen White, the editor, then secretary to the chancellor of the University, and who now is curator of the Thayer Art Collection.

Already before obtaining the B.A. degree at the University of Kansas in 1905, Roy L. Moodie came under the tutelage of Prof. S. W. Williston, shortly before the latter accepted the chair of Vertebrate Paleontology at the Uni-



ROY LEE MOODIE

versity of Chicago. There, Moodie continued as a pupil of Williston, a fellowship providing the means for further study. Upon earning the Ph.D. degree in 1908, he taught biology for several months as a substitute teacher in the Missouri State Normal School at Warrensburg. Here, during the gay spring in the beautiful Ozark hills, he courted Catherine McKennon Wood of Kansas City, teacher in the art department of the same school. Their marriage occurred in June, 1910. Three children were born to them: William Ross, Catherine Ann, and Sarah Lee.

In the summer of 1908, Doctor Moodie was appointed instructor of zoology at the University of Kansas, and a year later promoted to assistant professor, in which capacity he served from 1909 to 1913. In that year, he accepted the position of professor of anatomy at the College of Medicine of Baylor University, in Dallas, Texas, and in the following year became associated as instructor in anatomy with Dean Albert Chauncey Eycleshymer at the College of Medicine of the University of Illinois. Here, he ranked as associate in 1915-1916, as assistant professor from 1916 to 1920, and as associate professor from 1920 to 1924. At that time the increasing severity of Parkinsonian disease, that had come upon him in his young manhood, forced him to accept the less strenuous task of research librarian which post was created for him and which he held until 1928, when he retired to California.

Doctor Moodie was a prolific writer. His published papers and works number well above two hundred. His papers appeared in many different periodicals, such as the *American Journal of Anatomy, Biological Bulletin, Journal of Morphology, American Naturalist, Journal of Geology, Bulletin of the American Museum of Natural History, Surgery, Gynecology, and Obstetrics, Journal of Parasitology, Proceedings of the United States National Museum, Annals of Medical History, Scientific Monthly*, etc. The limited space does not permit the publication here of the extensive list of titles. Such a list is deposited in the files of the Department of Anatomy of the University of Illinois.

Of his earlier, purely paleontological work, the extensive monograph "Coal Measure Amphibia," published in 1916, is probably best known. In the course of his investigations he became more and more impressed by the evidence of disease in the extinct animals, as revealed in their skeletal remains. Already by the year 1916, he had published some fifty papers dealing chiefly with subjects in paleontology, anatomy, zoology, and vertebrate evolution. Now, in that year, the titles of two papers read: "Mesozoic Pathology and Bacteriology" and "Bacteriologic and Pathologic Evidences in past Geologic Ages." Such observations were so fascinating that he soon gave his entire time to the search, description and classification of the different kinds of lesions found in fossil specimens. In 1918, he began that extensive series of papers known as "Studies in Paleopathology" which continued to appear until the end of his life. In 1921, he edited for Lady Ruffer the memorial volume "Studies in the Paleopathology of Egypt," containing the work of Sir Marc Armand Ruffer, who was killed in the Great War. Two years later his own book "The Antiquity

of Disease" appeared. Both volumes were published by the University of Chicago Press.

In addition to his stamina for tireless and productive research in a rare and difficult field, Doctor Moodie was strongly imbued with the spirit of popularizing science, for which he had peculiar aptitude right from the start of his career. Without doubt, his sense of humor, delight in tales, and his facile style were the mainspring of this inclination. It is reflected in the titles of most of his popular articles, such as: "When Winged Dragons Sailed over Kansas"; "The Sea Serpent had a Toothache"; "How Cancer Existed Millions of Years Ago"; "A Curious Fossil Cemetery"; "Evolution's Most Romantic Moment"; "Stone Age Man's Cure for Headache"; "Mammoth Soup"; "Fossil Weather"; "A Mammoth's Deformed Wisdom Tooth"; "What the Mummies Reveal"; "What Bad Teeth Did to a Pre-historic Indian"; "Stiff Back in the Saber-Tooth." Many of his articles were reviewed and even reprinted in part in notable magazines and newspapers.

Among anatomists Doctor Moodie is best remembered for his brief biographical sketches of 800 anatomists in the book on "Anatomical Names" by Eycleshymer, which was published in 1917.

Although Doctor Moodie was elected to membership in a number of scientific societies, such as Sigma Xi, the American Association for the Advancement of Science, American Paleontological Society, American Anatomists, and the Society of Zoologists, he was averse to taking a personal part at the annual meetings. Only once did he relent to present a paper at the session of the Paleontological Society, on December 28, 1920, in Chicago.

Though teaching anatomy, his thought and interest was not devoted to it, if my conjecture is correct. He made no pretense in that direction, and in the classroom he was unafraid to admit to the student his lack of knowledge in much of its field. He abhorred the dissecting laboratory, and he often expressed his aversion to it in curious twists of profanity.

In 1923, Doctor Moodie spent his sabbatical year in California, and there established the contacts which after 1928 were to bring him the happiest period of his life, though its years were destined to be short. Moreover, he realized what an exceptional opportunity the Rancho La Brea Collection of Pleistocene fossils in the Los Angeles Museum offered to his work. For a year or two after taking up his abode near Los Angeles in 1928, he was connected with the College of Dentistry of the University of Southern California as professor of Paleodontology. It was during this period that he began the publication of a series of papers, entitled "Studies in Paleodontology," which became as extensive as the series in Paleopathology already mentioned. In 1930, he was appointed research associate of the Wellcome Research Institution of London, England, which gave him full leisure to investigate without a thought of pecuniary care.

Last summer, while on a journey to the West, I visited him in his workroom in the Los Angeles Museum, and I found confirmed what letters had intimated, that he was enjoying himself to the full. He spoke in glowing

terms of Sir Henry Wellcome's personal visit, interest, and patronage, and he showed with pride the case on case of specimens reaching to the ceiling, and the three large volumes he was preparing on the "Paleopathology of the California Saber-Tooth, and other Felidae." Despite his nervous affliction, he was radiant with healthy color, cheerfulness, and keenness of mind. He related how on week-ends he would bask in the hot sun and sands of the Mojave Desert, which were more beneficial to him than all the sedatives in the world.

Doctor Moodie's death resulted from an accidental fall in the patio of his home in Pasadena on February 10; the shock following a fractured head of the femur associated with a series of hemorrhages carried him away. In a letter, Mrs. Moodie asks if the clock had not struck twelve for him, for only a few days before he had written finis to the monumental work just named, and had made arrangements for the packing of the specimens for shipment to the Wellcome Museum in London. He had dropped the remark that he intended to rest a bit before taking up the next problem.

It is always difficult to evaluate and to define in a few words a man's character and personality. I believe I caught his individual traits most clearly during our lunches in his room here at the college. As I ate my sandwich, he delved into the drawer of his desk which was stocked with apples, peanuts and crackers. His enthusiasm was infectious, for while crunching a nut he would haul forth joyously his latest paleontological acquisition and exclaim: "Do you see what I see?" He went into equal raptures about a good story. He held to his opinions staunchly, but did not insist that anyone else should agree with him. He was generous to a fault, and in later years learned to be tactful in the face of his driving will which finished what it started. His was essentially a cheerful, hopeful, and undaunted nature. From his conversation one could gather that he enjoyed his children and his home to the fullest.

It is to his family that a memorial leaf is dedicated, bearing the following inscription, and the signatures of former colleagues who knew him best:

> To Roy L. Moodie—one time Associate Professor of Anatomy in the College of Medicine, University of Illinois—who in the face of life long physical suffering maintained an unflinching courage and unquenchable optimism, which inspired his great productiveness and carried him to the dominant place in the science of Paleopathology.
>
> In token of their admiration of his personality and achievements, his former colleagues affix their signature.

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EDWARD ELLERY,
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